

SURGICAL SUCTION IRRIGATOR

FIELD OF THE INVENTION

This invention relates to a surgical suction and irrigation system, and more particularly to one adaptable
5 to use in endoscopic surgery.

BACKGROUND OF THE INVENTION

U.S. Patent 5 484 402, assigned to the Assignee of the present invention, discloses a surgical suction irrigation system suitable for endoscopic and other
10 surgical procedures. Such system includes a remote pumping unit comprising batteries and a motor driven pump adapted for location adjacent a conventional irrigation liquid source, (such as a conventional liquid irrigation bag), and a handpiece having suction and irrigation
15 valves and a pump motor control switch. An irrigation liquid hose and electrical conductors connect the handpiece to the irrigation liquid pumping unit. Actuation of the handpiece irrigation liquid valve opens a path therethrough from the irrigation liquid hose and
20 simultaneously actuates the switch to energize the pump motor and pump irrigation liquid from the irrigation liquid bag therethrough and through the handpiece to supply a surgical site.

In a continuing effort to improve on surgical
25 suction irrigation systems, particularly endoscopic suction irrigation systems, the present invention has been developed.

Further objects and purposes of the present invention will be apparent to persons acquainted with
30 apparatus of this general kind upon reading the following description and inspecting the accompanying drawings.

SUMMARY OF THE INVENTION

In an embodiment of the invention, a surgical fluid flow handpiece provides a range of relatively low flow rates with relatively fine manual control in selecting a flow rate in such relatively low range, and also provides for manual selection of a relatively high flow rate namely a flow rate well above such range.

In an embodiment of the invention, the handpiece is shaped to complement the shape of a user's hand.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a pictorial view of a surgical handpiece embodying the invention and showing, schematically, the structure for connecting same to suction and irrigation sources as well as to a surgical site.

Figure 2 is an exploded view of the Figure 1 handpiece.

Figure 3A is a pictorial view of the inverted top tub of the Figure 1 handpiece.

Figure 3B is a sectional view of the Figure 1 handpiece taken along the common plane of the length axes of the irrigation and suction through passages and the communicating conduit.

Figure 3C is a bottom view of the top inverted tub of the Figure 1 handpiece.

Figure 3D is a fragmentary, partly broken, sectional view generally taken on the line 3D-3D of Figure 3C.

Figure 3E is an enlarged fragment of Figure 3D, detailing one of the sleeve retaining ridges.

Figure 3F is an enlarged sectional view substantially taken on the line 3F-3F of Figure 3C.

Figure 3G shows a fragment of Figure 3E and illustrates the retained engagement of the shell by the Figure 3E ridge.

5 Figure 3H is an enlarged fragment of Figure 3B showing the interior bottom portion of the suction valve barrel 403G.

Figure 3I is a fragmentary sectional view substantially taken on the line 3I-3I of Figure 3D.

Figure 3J is an enlarged fragment of Figure 3C.

10 Figure 4A is a pictorial view of the suction leak control sleeve of the Figure 1 handpiece.

Figure 4B is a bottom view of the Figure 4A sleeve.

Figure 4C is a central cross sectional view of the Figure 4A sleeve substantially taken on the line 4C-4C of
15 Figure 4D.

Figure 4D is a side view of the Figure 4A sleeve.

Figure 5A is a pictorial view of the suction valve body of the Figure 1 handpiece.

Figure 5B is a partially broken elevational view of
20 the Figure 5A valve body.

Figure 5C is an enlarged cross sectional view taken on the line 5C-5C of Figure 5B.

Figure 5D is a central cross sectional view substantially taken on the line 5D-5D of Figure 5B.

25 Figure 5E is a top view of the Figure 5A valve body.

Figure 5F is a sectional view taken substantially on the line 5F-5F of Figure 5D.

Figure 6A is a pictorial view of the seal spool of the Figure 1 handpiece.

30 Figure 6B is an elevational view of the Figure 6A seal spool.

Figure 6C is a sectional view substantially taken on the line 6C-6C of Figure 6B.

Figure 6D is a sectional view substantially taken on the line 6D-6D of Figure 6B.

Figure 7A is a top view of the suction pushbutton of the Figure 1 handpiece.

5 Figure 7B is a sectional view substantially taken on the line 7B-7B of Figure 7A.

Figure 7C is a bottom view of the Figure 7A pushbutton.

Figure 8A is a fragmentary schematic top view of the
10 Figure 1 handpiece in the suction leak closed, suction valve closed condition.

Figure 8B is a fragmentary schematic side view of the Figure 8A handpiece.

Figure 8C is an enlarged, fragmentary, schematic
15 sectional view substantially taken on the line 8C-8C of Figure 8B.

Figure 9A is a view similar to Figure 8A but with the suction leak sleeve in its open position.

Figure 9B is a view similar to Figure 8B but with
20 the suction leak sleeve in its open position.

Figure 9C is an enlarged, fragmentary, schematic sectional view substantially taken on the line 9C-9C of Figure 9B.

Figure 9D schematically illustrates the finer
25 control of suction flow, and very low suction flow levels, provided by the indented end configuration of a window in the suction leak control sleeve of Figure 2.

Figure 10A is a view similar to Figure 8A but with the suction valve in its full open position.

30 Figure 10B is a view similar to Figure 8B but with the suction valve in its full open position.

Figure 10C is an enlarged fragmentary schematic cross sectional view substantially taken on the line 10C-

10C of Figure 10B with the suction leak sleeve in its closed position.

Figure 10D is a view similar to Figure 10C but with the suction leak sleeve in its open position.

5 Figure 11A is a view generally similar to Figure 8B and wherein the irrigation valve is in its full closed position.

Figure 12A is a view similar to Figure 11A but showing the irrigation valve in a partially closed
10 condition.

Figure 13A is a view similar to Figure 11A but showing the irrigation valve in its fully open position.

Figure 14A is an enlarged, fragmentary, schematic central cross-sectional view substantially taken on the
15 line 14A-14A of Figure 3B and showing the suction valve in its closed condition.

Figure 14B is a fragment of Figure 14A but showing the suction valve in its full open condition.

Figure 15A is a bottom pictorial view of the
20 irrigation pushbutton of the Figure 1 handpiece.

Figure 15B is a fragmentary pictorial view of the Figure 2 switch elements installed in the top tub of the Figure 2 handpiece, looking generally upward and rearward in the Figures 1 and 2 orientation of the handpiece, and
25 showing the switch element mounting area of Figures 3F and 3J.

Figure 15C is a fragmentary schematic view taken generally on the line 15C-15C of Figure 3F and showing the switch actuator foot in an intermediate position with
30 respect to one of the Figure 2 switch elements.

Figure 15D is a schematic sectional view substantially taken on the line 15D-15D of Figure 15C and showing alternate positions of the switch actuator foot

and switch elements, including open, intermediate and closed positions.

Figure 16A is a fragmentary, schematic, central cross sectional view of the irrigation valve in its fully closed position, and substantially as taken on the line 16A-16A of Figure 3B.

Figure 16B is a view similar to Figure 16A and showing the irrigation valve unit in a partially closed condition.

Figure 16C is a view similar to Figure 16A but showing the irrigation valve unit in its fully open position.

Figure 17A is a pictorial view generally similar to Figure 1 but showing the suction and irrigation tubes extending from the handpiece.

Figure 17B is a view similar to Figure 17A but showing the handpiece gripped by the hand of a user in one position.

Figure 17C is a view similar to Figure 17B but showing the handpiece gripped by the hand of the user in another position.

Figure 17D is a side view of the assembled top and bottom tubs of the Figure 1 handpiece showing the profile of the handpiece shell.

DETAILED DESCRIPTION

This application incorporates by reference the disclosure (e.g. specification and drawings) of co-pending U.S. Application Serial No. 08/769 428 filed December 19, 1996 (Attorney Ref: S*E 139B) of Nelson, et al. assigned to the Assignee of the present invention, namely Stryker Corporation, same being a continuation of U.S. Application No. 08/769 428, filed December 19, 1996, now abandoned, in turn a continuation in part of U.S.

Application No. 08/176 130 filed December 30, 1993,
issued as U.S. Patent 5 484 402 on January 16, 1996.

Turning now to the present application drawings,
Figures 1 and onward disclose an inventive handpiece 26G.

5 In some instances, parts of the handpiece 26G will carry
the same reference numerals as generally corresponding
parts of the handpiece 26D described at pages 28-48 of
the above mentioned incorporated-by-reference application
No. 08/769 428.

10 It will be understood that the inventive handpiece
26G may be used in a variety of orientations, for example
in the Figure 1 orientation, in an orientation turned
upside down therefrom, or in other orientations as
desired and convenient. However, for convenience in
15 reference, in the present discussion the words "top" and
"bottom", and words of similar import, shall refer to the
handpiece 26G in its orientation of Figure 1.

The components of the handpiece 26G are preferably
of a suitable rigid molded plastics material, exceptions
20 being noted below.

The handpiece 26G (Figure 1) comprises an
ergonomically rounded, easily gripped shell 400G. The
shell 400G here comprises a generally downwardly opening,
inverted, top tub 401G (Figure 2), the bottom of which is
25 fixedly closed by an upward opening bottom tub 610. The
tubs are fixed together, here at least by integral pins
611 depending from the top tub 401G and fixedly received
in integral sockets 612 upwardly opening in the bottom
tub 610.

30 The inverted top tub 401G (Figure 2) comprises
upstanding, spaced, front and rear valve barrels 402G and
403G respectively. The valve barrels 402G and 403G
depend below the sidewall 405G of the top tub 401G. The

front barrel 402G extends farther above the top wall 410G than does the rear barrel 403G. The valve barrels 402G and 403G house respective suction and irrigation valve units 651 and 650 hereafter discussed.

5 An elongate rigid conduit 430G (Figure 2) is fixed, and preferably integrally molded, at the top of the top tub opposite side wall 404G. To facilitate sealed removable attachment of a surgical tip TP (Figure 1) engagable (e.g. through a cannula CA) with a surgical
10 site SU, the conduit front end portion 431G may be externally threaded in front of an annular seal ring groove 434G (Figure 2) which receives a resilient seal ring (e.g. an O-ring 437G). The threads are here shown as broken by oppositely facing flats 616. The conduit
15 rear end portion 432G may be of enlarged diameter and internally threaded to receive a closure plug 440G in sealed, removably fixed relation therein. A resilient seal ring (e.g. an O-ring 442G) on the closure plug 440G provides a liquid seal with the conduit 430G. In the
20 embodiment shown, an annular, internally and externally threaded adapter 620 may be radially interposed between the threaded portions of the conduit rear portion 432G and plug 440G. Removal of the plug 440G and/or adapter 620 allows insertion of a variety of surgical instruments
25 (e.g. an electrocautery probe) forwardly through the central through passage 441G of the conduit 430 to engage the surgical site SU (Figure 1), for example as discussed in more detail in the above mentioned application incorporated by reference herein.

30 Irrigation liquid and suction ducts 624, 625 and 626, 627 (Figure 3A) are fixed to, and preferably integrally molded in, the top wall 410G (Figure 3A) of the top tub 401G. The irrigation duct 624, 625 has rear

and front portions 624 and 625 respectively which flank the front (irrigation) valve barrel 402G. The suction duct 626, 627 has rear and front portions 626 and 627 which flank the rear (suction) valve barrel 402G. The front duct portions 625 and 627 intersect the conduit 430G. The ducts 624, 625 and 626, 627 extend generally rearwardly at an acute angle (here about 22° and preferably between 15 and 30°) to the conduit 430G.

The ducts 624, 625 and 626, 627 have respective, coaxial, through passages 630 and 631 (Figure 3B) whose central length axes are parallel to each other and are coplanar with the central length axis of the conduit 430G. The through passages 630 and 631 communicate with the central through passage 441G of the conduit 430G and extend rearwardly and angularly therefrom diametrically through the valve barrels 402G and 403G respectively and open through the rear ends of the ducts 624, 625 and 626, 627 respectively. The central length axes of the irrigation and suction passages 630 and 631 perpendicularly intersect respective upstanding length axes of upstanding, coaxial, bores 454G and 455G, respectively, of the front and rear valve barrels 402G and 403G respectively, as generally seen in Figures 3A and 3B.

The rear portions of the through passages 630 and 631 are defined by respective nipples 632 and 633 (Figure 3B) which are fixed to and extend rearward from the valve barrels 402G and 403G respectively. The nipples 632 and 633 are disposed radially loosely in generally rearwardly opening duct recesses 634 and 635 respectively to enable the nipples 632 and 633 to sealingly and releasably fixedly receive thereon corresponding ends of a flexible irrigation supply tube 23G and flexible suction tube 33G,

respectively. In this way, the conduit 430G (Figure 2) may communicate, e.g. as in the incorporated-by-reference application, through a pump unit 10G with an irrigation liquid source IL and suction source SS through the
5 respective through bores 454G and 455G (Figure 3B) of the valve barrels 402G and 403G, respectively.

A generally rearward opening hole 640 at the join of the top and bottom tubs 401G and 610, and a generally rearward opening notch 641 (Figure 1) in the top portion
10 of the inverted top tub 401G, open rearward from the recesses 634 and 635 respectively and are sized to allow easy insertion of the flexible tubes 23G and 33G respectively into such recesses and thus into sealed engagement on the respective nipple 632 and 633 (Figure
15 3B). A generally upward and sideward opening notch 642 in the central bottom edge of the top tub 401G, between the recess 63A and hole 640, aids installing the tube 23G on the nipple 632.

The bores 454G and 455G (Figure 2) of the respective
20 valve barrels 402G and 403G accommodate respective irrigation suction and valve units 650 and 651.

The suction valve unit 651 (Figure 2) includes a suction leak control sleeve 660, a coil spring 661, a seal spool 662, a valve body 663, an annular seal (e.g.
25 an O-ring) 664 and a push button 665.

The sleeve 660 (Figures 4A-D) is a generally tubular member having a substantially cylindrical through bore 670 extending longitudinally therethrough and topped by a radially inwardly sloped chamfered edge 671 (Figure 4C).
30 From the top, the outer periphery of the sleeve 660 includes a generally cylindrical top portion 672, a radially outwardly extending flange 673 having circumferentially spaced (here diametrically opposed),

finger engagable, rotation inducing arms 674, an intermediate portion 675, a shallow, axially elongate, cylindrical groove 676 and a downward tapered bottom rim 677. The intermediate portion 675 is gently (hereat an angle of 1° to 3°, preferably 2°) downwardly tapered. Substantially rectangular keys 680 are fixed at the joiner of the flange 673 to the tapered intermediate portion 675. The keys are preferably diametrically opposed and circumferentially offset by about 90° from the arms 674. Circumferentially elongate windows 681 and 682 open through the peripheral wall of the sleeve 660 intermediate the height of the intermediate tapered portion 675, in axially spaced relation between the keys 680 and groove 676. The top and bottom edges of the windows 681 and 682 are substantially parallel and lie in corresponding, substantially diametrical planes. The ends of the windows are somewhat rounded, as seen in Figures 4A, C and D. Indeed, one end of the windows 681 is, along its upper edge provided with a tapered circumferentially extending indent 683 (Figures 4A and 4D). The windows are circumferentially spaced by peripheral wall portions 684 of the sleeve intermediate portion 675.

The valve body 663 (Figures 5A-E), from the top, includes an elongate, generally cylindrical trunk 690, an elongate, reduced diameter, constant cross-section waist 691, a radially outwardly extending hip flange 692 having the same outside diameter as the trunk 690, and a pair of depending, downwardly divergent, resiliently bendable, leaf-spring-like legs 694 terminating at their lower ends in respective, radially outwardly extending, somewhat upward angled feet 695.

The trunk 690 is separated into top and bottom portions 700 and 701 by an annular groove 702 which receives the seal ring 664 (Figure 2). A cross-shaped (cruciform) recess 703 opens coaxially through the top
5 face 704 of the trunk 690. A generally rectangular cross-section, diametrical through opening 705 extends through the trunk top portion 700 in spaced relation above the groove 702. The diametrical through opening 705 is at the bottom of and in communication with the
10 cruciform recess 703. Two diametrically opposed axial grooves 710 of the cruciform recess 703 intersect the diametrical through opening 703. The central bottom surface of the cruciform recess 703 is defined by a coaxial, symmetrical cross-section, upstanding wedge 711
15 (Figure 5D) having upwardly convergent sides, each facing a corresponding cruciform recess axial groove 710 and end of the diametrical through opening 705. The wedge 711 thus projects upward into the diametrical through opening 705. The lateral width of the wedge 711 is substantially
20 less than the distance between the opposed bight faces of the axial groove 710, such that the wedge 711 is substantially spaced from the top of the diametrical through opening 705 and the opposed faces of the annular grooves 710, and allows considerable space at the
25 intersection of each such axial groove 710 with the corresponding end of the diametrical through opening 705, as readily seen in Figure 5D.

A diametrical through passage 720 (Figures 5A and 5B) in the trunk bottom portion 701 is here of
30 substantially rectangular cross-section, which cross-section is substantially larger than that of the diametrical through opening 705 and occupies much of the height of the trunk bottom portion 701. In the

embodiment shown, the diametrical axes of the through opening 705 and through passage 720 are slightly circumferentially offset, as well as being axially spaced apart. The outer ends of the diametrical through passage 5 720 are each circumferentially widened by a clockwise facing (seen from the top) bevel 721 (Figure 5F).

The waist 691 (Figure 5A) comprises a reduced diameter, longitudinally extending, cylindrical core 724 flanked by diametrically outwardly protruding, axially 10 extending ribs 725.

The seal spool 662 (Figures 6A-6D) has a coaxial through passage 730 whose inner periphery is indented by two axially extending, diametrically opposed grooves 731. The spool has a coaxial radially outwardly extending 15 circular end flanges 732 of generally rounded periphery and which are axially symmetrically opposed as seen in Figure 6B. The end flanges 732 axially flank a substantially cylindrical mid-portion 733 of reduced diameter. Ribs 734 protrude radially outward from the 20 central portion 733 and extend axially between the flanges 732. The ribs 734 are diametrically oppositely extending and preferably are coplanar with the grooves 731 and with the central length axis of the seal spool 662. The seal spool is of resiliently deformable 25 material, preferably as conventionally used for fluid seals, such as a suitable resilient polymer or natural rubber.

The pushbutton 665 (Figures 7A-7C) comprises an inverted shallow cup 739 of generally D-shape in plan 30 (Figure 7A), having a peripheral wall 740 and an end wall 741. A portion 742 of the peripheral wall 740 is substantially straight and the diametrically opposite portion 743 of the peripheral wall 740 is convexly

rounded. At a location preferably slightly offset rightwardly and above center (as seen in Figure 7A), a pair of laterally spaced, leaf-spring-like legs 744 (Figure 7B) project slightly divergently from the interior face of the push-button end wall 741 toward the open end of the cup 739, and terminate in acutely upwardly angled, oppositely projecting feet 745, which here extend just beyond the free edge of the push-button peripheral wall 740. Laterally opposed and spaced posts 746 similarly extend from the interior surface of the push-button end wall 741 toward the open end the cup 739 and beyond the free edge of the peripheral wall 740 to about same extent as the feet 745. The legs 744 and posts 746 alternate circumferentially around a common center, indicated at 747 in Figure 7C, and are preferably equally circumferentially spaced. Spaced opposed holes 748 open through the push-button end wall 741 (Figures 7A and 7B) along the outboard edges of the corresponding legs 744.

The suction valve unit 651 may be assembled as follows. The O-ring 664 (Figure 2) is resiliently stretched over and slid down along the top portion 700 of the valve body 663 and snaps into the annular groove 702. The resilient seal spool 662 is radially resiliently stretched sufficient to pass upward over the legs 694 and hip flange 692 and snap into place between the trunk bottom portion 701 and flange 692, with waist ribs 725 (Figure 5C) received snugly in circumferentially fixing relation in the axial grooves 731 in the seal spool 662. This fixes the seal spool 662 on the valve body 663 generally indicated in Figure 5B.

Thereafter, the push-button 665 (Figure 7B) is snap fitted atop the valve body 663 as generally indicated in

Figures 1 and 14A. More particularly, the push-button legs 744, with their feet 745, are pressed downward into the valve body axial grooves 710 (Figures 5D and 7B). Simultaneously, the push-button posts 746 enter the
5 remaining axial grooves 712 of the cruciform recess 703 and the top of the valve body 663. The springy legs 744 press their feet 745 radially outward against the outer walls of the grooves 710. Continued insertion of the feet 745 into the valve body diametrical through opening
10 705 allows the springy legs 744 to spring apart and seat their feet 745 outward of their respective valve body axial grooves 710 to entrap same under the top, outboard faces of the diametrical through opening 705, whereafter the push-button end wall 741 comes to rest on the top 704
15 of the valve body 663, with the peripheral wall 740 of the push-button 665 overhanging part of the valve body top portion 700.

While not normally done, it is possible to remove the push-button 665 from the valve body 663 by inserting
20 a slim rigid probe (not shown) radially into the outer end of the diametrical through opening 705 to press the corresponding foot 745 radially inward against the wedge 711 which displaces it upward along the corresponding groove 710. This can be done to both feet 745 but doing
25 it to one is normally sufficient to pop the push-button 665 off the valve body 663.

Similarly, a slim rigid probe inserted in one or both of the holes 748 (Figure 7B) can resiliently bend the corresponding leg 744 of the push-button 665 radially
30 inward to release the foot 745 from the diametrical through opening 705, to thereby pop the push-button 665 off the top of the valve body 663 (Figure 5D).

The sleeve 660 (Figure 2) is of a generally self-lubricating, somewhat resilient and seal-like material, such as polyethylene. The sleeve 660 inserts down into the open upper end of the suction valve bore 455G. The sleeve tapered bottom rim 677 (Figure 4A) resiliently snaps down over, and is retained against upward displacement by, circumferentially spaced, semi-circular ridges 753 (Figure 3E) fixed near the bottom of the valve bore 455G. The ridges 753 have sloped, upwardly and radially inward facing ramp surfaces 754 and downward facing surfaces 755 (Figure 3E). The slope of the ramp surface 754 preferably compliments the radially outward and downward facing slope of the sleeve tapered bottom rim 677. The semi-circumferential ridges 753 thus fixedly retain the sleeve 660 in its installed position within the valve bore 455G.

The upper portion 736 of the suction valve bore 455G is downwardly convergently tapered at angle in complement to and preferably the same as that of the sleeve tapered intermediate portion 675 (Figure 4C), to provide a taper-snugged, rotative seal therebetween in the assembled handpiece 26G.

The upper edge of the suction valve barrel 403G (Figures 3A and 3D) is stepped to form a pair of axially shallow, diametrically opposed notches 760. As seen from the top, the centers of the notches 760 are on an imaginary line angled slightly clockwise from the common central plane of the valve bore 455G and suction duct 626. With the sleeve installed in the suction valve bore 455G, and as shown schematically in Figure 3D, the sleeve flange 673 rides atop the valve barrel 403G and the sleeve keys 680 ride in respective ones of the notches 760 to limit rotation of the sleeve 660 to an acute angle

arc of about 50° to 70° , preferably of about 60° .

Radiating line indicia 761 (Figures 3A, 8C and 9C) are fixed (e.g. molded onto) the top of the conduit 430G, are on radii of the central axis of the suction valve bore 455G, and are spaced along an arc over which one of the sleeve arms 674 rotates to show the user the rotative position of the arms 674, and thereby of the windows 681 and 682 of the sleeve 660 with respect to the suction through passage 630. The windows 681 and 682 are located circumferentially on the sleeve such that they continuously open to the suction through passage 631 through the rotation of the sleeve 660, defined by interference of the keys 680 and notches 760 and shown by the rotation of the corresponding sleeve arm 674 along the arc of the indicia 761.

Fixed to, and coaxially upstanding from, the bottom wall 764 of the suction valve barrel 403G (Figures 3H, 3I and 14A) is a circular, cylindrical (or slightly upward tapered) boss 765. An upstanding, generally rectangular, cross-section hole 771 extends diametrically through the boss 765 from the barrel bottom wall 764 (Figure 3D) partway to the top of the boss. A generally rectangular, diametrical top slot 770 extends partway across the top 773 of the boss, opens to the mid-portion of the diametrical hole 771 and forms an upward continuation of the latter. The diametrical top hole 771 and slot 770 leave chordal peripheral rim portions 774 diametrically opposed at the top portion of the boss 765. A generally rectangular, diametrical bottom slot 775 opens through the bottom wall 764 and forms a smooth downward continuation of the diametrical top hole 771. The bottom slot 770, top hole 771 and bottom slot 775 are of the

same width and have a common central plane, as well as common side walls 780, as in Figure 3I.

5 Arcuate openings 781 (Figure 3H) through the barrel bottom wall 764 are diametrically opposed and extend from the boss 765 to the peripheral wall 782 of the suction valve barrel 403G.

10 With the sleeve 660 already installed in the suction valve barrel 403G as above described, the assembling of the suction valve unit 651 (Figure 2) may continue as follows. The spring 661 is dropped into the sleeve 660, wherein the spring 661 (Figure 14A) rests on the bottom wall 764 of the valve barrel 403G with its bottom portion surrounding the boss 765.

15 Thereafter, the valve body 663, with the seal spool 662, annular seal 664 and push button 665 installed thereon, as above described, is pushed downward, feet 695 first, into the sleeve 660 such that the legs 694 and feet 695 loosely enter the interior of the spring 661 and the hip flange 692 comes to rest atop the spring 661.

20 Further insertion of the valve body 663 causes the descending hip flange 692 to partially compress the spring 661 as the feet 695 enter, are resiliently pushed toward each other by, and pass downward through the generally rectangular slot 770 (Figures 3H, 3I and 14A)

25 in the top of the table 765 whereupon the feet spring 695 resiliently spring apart so as to abut and become entrapped beneath the chordal peripheral rim portions 774 of the table 765. The spring 661 resiliently urges the feet 695 upward against such chordal peripheral rim

30 portions 774.

 This leaves the suction valve unit 651 in its normal, at rest, closed, axially up position of Figure 14A, wherein the push button 665 is spaced well above the

top of the sleeve 660. In this closed position, the seal
spool 662 is vertically centered on the suction leak
control sleeve windows 681 and 682 and on the irrigation
through passage 631, which are vertically aligned with
5 each other as above discussed with respect to Figure 3D.
Also, in this suction valve unit closed position, the
flange 692 is spaced below the windows 681 and 682 and
suction through passage 631, whereas in sequence upward
therefrom are the suction valve diametral through passage
10 720, the annular seal 664 and the suction leak control
sleeve top flange 673. In this closed position, the
resilient top and bottom end flanges 732 of the seal
spool 662 snugly engage and circumferentially seal
against the interior wall of the sleeve 660, immediately
15 above and below the sleeve windows 681 and 682, and so
positively prevent leakage of fluids from the passage 631
along the interior of the sleeve 660 past the top and
bottom sealing spool end flanges 732.

Should for any unexpected reason it be desired to do
20 so, the valve body 663 (Figure 14A) can be removed from
the valve barrel 764 by displacing the feet 695 toward
each other sufficient to clear the chordal peripheral rim
portions 774 of the boss 765, as by means of a suitable
thin probe element (or tweezer like pair of probe
25 elements) inserted upward through the slot 775 in the
bottom wall of the valve barrel 403G.

Full manual depression of the push button 665
(Figure 14B and, for convenience in the illustration,
Figure 1) displaces the valve body 663 downwardly further
30 into the sleeve 660, thus displacing the feet 695
downward below the bottom wall 764 of the valve barrel
403G and abutting the hip flange 692 with the top of the
boss. This substantially fully and coaxially

communicates the valve body diametral through passage 720 with the sleeve windows 681 and 682 and the suction through passage 631. The suction valve unit 651 is thus now in its normal, full open position.

5 This provides suction flow from the surgical site SU (Figure 1), through the front portion of the conduit 430G, the front portion of the through passage 631 (Figure 14B), the window 681, the valve body diametral through passage 720, the window 682, the rear portion of
10 the suction through passage 631, the nipple 633 (Figure 3B), the flexible tubing 33G (Figure 1), to a suction source SS, e.g. conventional hospital operating room suction source. The resilient O-ring 664 and upper end flange 732 of the seal spool 662 circumferentially seal
15 against the inner periphery of the sleeve 660, and thus prevent fluid leakage between the upper and lower portions of the sleeve 660 and the valve body diametral through passage 720.

 Upon release of user finger pressure on the push
20 button 665, the spring 661 returns the valve body 663 and push button 665 to their upper, off position of Figure 14A, thereby closing suction flow through the diametral through passage 720 of the suction valve unit 651.

 The suction valve unit 651 is typically opened (by
25 depression of the push button) to remove bits of tissue, entrained in liquid, from the surgical site SU, generally as in the incorporated-by-reference application, although, as seen herein, the suction valve unit 651 differs substantially in structure from that of the
30 incorporated-by-reference application.

 Different partial depressions of the suction pushbutton 665 correspondingly partially open the suction valve unit 651 and thus provide different partial (not

full) suction flows. However, the user may find it difficult over time to maintain a given partial pushbutton depression location and thus a desired partial suction flow level.

5 At times it may be desirable to apply a smaller (i.e. partial), constant, adjustable, amount of suction to the surgical site, without the difficulty of trying to accurately set suction flow level by partial depression of the push button or trying to maintain a partially
10 depressed portion of the pushbutton 665 over a period of time. An example would be during removal of smoke from the surgical site SU during electrocautery. One of the types of surgical instruments that may be inserted into the surgical site SU, through the conduit 430G, is a
15 conventional electrocautery probe (not shown).

 Thus, the present invention allows the user, without depressing the push button 665, to set a desired partial suction flow from zero to a preselected fraction of the maximum suction flow which would occur if the push button
20 665 were fully depressed. Moreover, the present invention automatically maintains that set partial suction flow without further attention from the user, until the user elects to change that set partial suction flow (e.g. return it to zero). This partial suction flow
25 provided by the present invention may be referred to as the suction leak, or bypass, flow.

 As seen above, with the push button 665 and the valve body 663 in their up position (Figure 14A), due to the bias of the spring 661 and a absence of manual
30 depression of the push button 665 by the user, suction flow through the valve body 663 is positively prevented because the diametral through passage 720 is raised above and sealed from the suction through passage 631 of the

upper inverted tub 401G (Figure 2). The seal spool 662, in the closed (up) position (Figures 8C and 14A) of the suction valve body 663, is interposed in the suction through passage 631. With the suction leak control sleeve 660 in its Figure 8C closed rotative position, namely with its arm 674 at the counter-clockwise (as seen from the top) end of its arc of rotation, the axially extending seal spool ribs 734 seal against the portions 684 of the peripheral wall of the suction leak control sleeve 660, which portions 684 circumferentially separate the windows 681 and 682. Thus, the seal spool ribs 734 positively block suction flow therepast. Thus, there is no suction flow through the handpiece 26G (Figure 2) at all, because the valve body diametral through passage and the suction leak path (hereafter discussed) past the seal spool 662 are both blocked.

However, to set a desired partial suction flow in the suction through passage 631, (e.g. for electrocautery smoke evacuation), the user simply rotates the arms 674 in a clockwise (as seen from the top in Figure 9C) direction, until the desired level of partial suction is achieved. The material of the sleeve 660 is somewhat self-lubricating, such that a modest rotative force on the sleeve arms 664 suffices to rotate the sleeve 660 in the valve barrel 403G, without degrading the fluid seal therebetween.

The frictional engagement of the sleeve 660 with the suction valve barrel 403G and with the seal spool 662 frictionally maintains, against accidental displacement, the thus set circumferential position of the suction leak control sleeve 660 and hence the desired limited suction flow to the handpiece. At any time the user may again circumferentially displace a convenient one of the sleeve

arms 674 to increase, decrease or shut off this partial, "leak", suction flow through the handpiece 206.

In Figure 9C, the arms of 674 are shown adjacent their clockwise-most (maximum suction leak) position, wherein the sleeve peripheral wall portions 684 are spaced counter-clockwise from the corresponding ribs 734 of the seal spool 662. The ribs 734 thus face the windows 681 and 682. However, the windows 681 and 682 are circumferentially long enough to still communicate with the suction through passage 631 of the handpiece top tub 401G. As a result, there is an open suction flow passage (as represented schematically by the arrows in Figure 9C) through the front portion of the suction through passage 631, the sleeve window 681, the annular space between the interior of the sleeve 660 and the cylindrical midportion 733 of the seal spool 662, radially outward into the window 682, circumferentially in the window 682 around the exposed outer edges of the seal spool axial ribs 734, out the window 682 into the rearward portion of the suction through passage 631, through the nipple 633 and thus eventually to the suction source SS.

It will be seen from Figure 9C that incremental counter-clockwise rotation of the seal spool 662 (with its arms 674) will incrementally narrow the portion of the windows 681 and 682 between the seal spool axial ribs 734 and the circumferentially advancing sleeve peripheral portions (indicated at 684). This incrementally reduces the cross-section of the leak suction flow path. That cross-section is reduced to zero and suction flow stops when the circumferentially advancing peripheral portions 684 engage and seal against the outer edges of the seal spool axial ribs 734, as in Figure 8C above discussed.

The indent 683 (Figure 4) in one window end cooperates with the outer edge of the adjacent seal spool axial rib 734 to allow very fine adjustment of suction leak level at very low suction leak levels, by more
5 gradual reduction (or increase) of flow cross-section thereat, with the window 682 and the rest of the window 681 closed to suction flow.

Similarly, the indent 683 for a given sleeve rotation, makes more gradual the transition between no
10 suction flow and least suction flow.

Thus, Figure 9D schematically shows the more gradual increase in flow cross sectional flow area due to the indent 683 of the window 681 versus a hypothetical similar window 681' without the indent 683 (but with a
15 semi-circular window end like other ends of the sleeve windows 681 and 682. More particularly, Figure 9D shows several closely circumferentially spaced relative positions between the window 681 or 681' and the effective sealing edge of the seal spool rib 734 as the
20 sleeve 660 is rotated to advance the leading end of the window 681 or 681'.

However, for convenience in illustration, Figure 9D shows the several such relative positions by superposing several images of the sealing spool rib edge 734 on a
25 single image of the advancing end of the window 681 or 681'. More particularly, the barely closed position of the window 681 or 681' is indicated at CL and several slightly, but successively increasingly open positions of the leading window end, relative to the rib 734, are
30 indicated at OP1, OP2 and OP3 respectively. It will be seen at the Figure 9D initial open position OP1, that the flow cross sectional area AR1 of the window 681, provided by the indent 683, is substantially less than the flow

cross sectional area AR 1' provided by the generally circular end of the hypothetical window 681'. The same is true at successively assumed open positions OP2 and OP3 in Figure 9D. Thus, the indent 683 provides more
5 precise control of the magnitude of flow through the handpiece 26G at very low suction flow rates. Thus, the user can more precisely select the desired suction flow level in a narrow range of suction flows from very low down to zero. The user can thus, for example remove
10 electrocautery smoke from the surgical site without risk of otherwise changing conditions in the surgical site.

It is possible to provide irrigation liquid flow to the surgical site by means of the irrigation liquid valve unit 650 (Figure 2), hereafter discussed in more detail
15 even with the suction valve unit push button 665 depressed (from normal suction flow) or with the suction leak control sleeve 660 rotated for suction leak flow. Typically, this may occur in the presence of a tip having separate suction and irrigation paths inserted through
20 the conduit 430G and with the capability of separating, or sealing, from each other the portions of the tip communicating with the suction and irrigation valve units 651 and 650. An example is the suction pool tip shown in U.S. Patent 5 827 218 assigned to the Assignee of the
25 present invention.

Turning more specifically to the details of the irrigation valve unit 650 (Figure 2), components generally corresponding to those above described with respect to the suction valve unit 651 will carry the same
30 reference numerals with the suffix H added.

The irrigation valve unit 650 (Figure 2) is assembled substantially in the manner above discussed

with respect to the suction valve unit 651, except as follows.

Thus, the irrigation valve unit 650 (Figure 2) includes a coil spring 661H, a seal spool 662H, a valve
5 body 663H and an annular seal (e.g. O-ring) 664H preferably identical to the corresponding elements 661-664 of the suction valve unit 651. The irrigation valve unit 650 further includes a push button 690 which is generally similar to the push button 665 of the suction
10 valve unit, except as noted hereafter.

The bore 454G of the irrigation valve barrel 402G is cylindrical (not tapered) and smaller in inside diameter than the suction valve barrel 403G, and indeed is similar in inside diameter to the suction leak control sleeve 660
15 (Figure 2). Thus, the irrigation valve unit 650 includes no sleeve corresponding to the suction leak control sleeve 660 and the components 661H-664H fit snugly and slidably directly in the bore 454G of the irrigation valve barrel 402 with the annular seal (O-ring) 664H and
20 the annular end flanges 732 (Figure 6B) of the seal spool 662H sealingly bearing on the interior periphery of the suction valve bore 454G.

The opening and closing of the irrigation valve unit 650, by manual depression and release, respectively, of
25 the push button 650 to pass or block, respectively, irrigation liquid flow through the irrigation throughpassage 630 (Figure 3B) between the irrigation liquid source IL and the conduit 430G, is similar to that above described with respect to opening and closing, by
30 depression and release, respectively, of the suction push button 665 (Figure 2) to pass or block, respectively, suction flow through the suction throughpassage 631

(Figure 3B) between the conduit 430G and suction source SS, and so needs no further comment.

The straight perimeter portion 791 of the irrigation push button 790 faces rearward (toward the suction valve unit) rather than forward toward the surgical site. In addition, the irrigation push button 790 has a depending, generally L-shaped cross section leg 792 integrally fixed (and preferably integrally molded) at the rear, left (seen looking forward, or rightward, in Figure 2) corner of the push button 790. A generally rectangular, switch actuating foot 793 extends rearward from the bottom of the 792. The planes of the foot 793 and the front web 794 (Figure 15A) of the leg 792 are offset to provide a generally Z-shaped cross section for the combined leg/foot 792, 793 as seen at the bottom 796 of the foot in Figure 15A.

The top wall 410G (Figure 3A) of the top tub 401G is perforated by a substantially Z-shaped hole 800 located adjacent the conduit 430G, the suction duct front portion 627, and the irrigation duct rear portion 624. The Z-shaped hole 800 (Figure 3A) is located, sized and shaped to snugly but smoothly slidably receive the leg 792 and foot 793 downwardly therethrough. The leg 792 and its foot 793, pass down through hole 800 in the inverted top tub 401G as the valve body 663H passes down into the valve barrel 402G. Thus, in the installed, normally closed, upper position (Figure 1) of the irrigation valve unit 650 the foot 793 is spaced between the top wall 410G of the top tub 401G and the bottom of the front, irrigation liquid, valve barrel 402G (Figure 2).

A pair of switch carrier plates 413G (Figures 3J and 15 B-D) and a further pair of switch carrier plates 414G depend from the top wall 410G into the downward opening

cavity 410G of the inverted top tub 401G. The plates 413G and 414G are parallel to each other and preferably parallel to the length axes of the valve barrels 402G and 403G. The plates 413G and 414G are spaced inboard from
5 the side edges of the top tub 401G. The plate pairs 413G and 414G are spaced apart on opposite sides of the common diametral plane of the valve barrels 402G and 403G. Relatively narrow switch mounting gaps 420G and 421G laterally space apart the respective paired plates 413G,
10 413G and pair plates 414G, 414G. The parallel plates 413G extend rearward to and are fixed to the peripheral wall of the suction valve barrel 403G and extend forward toward the hole 800. Indeed, the outboard plate 413G has an extension portion 801 extending forward the length of
15 the rear arm 802 of the Z-shaped hole 800 and flanking the outboard edge thereof.

An electrical switch SWG (Figures 2 and 15B-D) comprises a pair of switch elements 510G and 511G of electrically conductive springy sheet metal, such as
20 copper or a suitable alloy.

The switch element 510G comprises a base plate 512G with gripper tabs 513G acutely angled with respect thereto. The switch element 510G further includes an electric connector terminal 514G and a switch contact
25 leaf 515G. The switch element 511G is of somewhat different shape, but includes a base plate 520G including gripper tabs 521G acutely angled with respect thereto, and an electric connector terminal 522G and switch contact leaf 523G extending therefrom.

30 The switch element 510G is fixed in the interior of the inverted tub 401G as follows. The base plate 512G is slidably inserted upward (in the orientation of Figures 2 and 15D) into the switch mounting gap 421G between the

depending switch carrier plates 414G. The gripping tabs 513G enter and become jammed in the switch mounting gap 421G to prevent the switch element 510G from accidentally leaving its operative position of Figures 15B and D,
5 within the inverted tub 501G. This leaves the electrical connector terminal 514G and switch contact leaf 515G outside the switch mounting gap 421G. The electrical connector terminal 514G thus lies between the outboard switch carrier plate 414G and the opposed sidewall of the
10 inverted tub 401G. The switch contact leaf 515G is resiliently self-urged toward the switch carrier plates 413G as more fully discussed hereafter.

The base plate 520G of the switch element 511G is inserted upward into the switch mounting gap 420G (Figure
15 15D) and is frictionally fixed therein by engagement of the gripping tabs 521G with the opposed inboard switch carrier plate 413G. The electrical connector terminal 522G is disposed between the outboard switch carrier plate 413G and the adjacent other inverted tub sidewall
20 adjacent the bottom of the outboard sidewall 413G. The switch contact leaf 523G extends upward along the outboard switch carrier plate 413G within the switch mounting gap 420G and into electrical contact with the switch contact leaf 515G of the switch element 510G to
25 complete an electrical connection between the two switch elements 510G and 511G.

It is convenient to install the switch elements 510G and 511G on their corresponding switch carrier plate pairs 413G and 414G with the irrigation valve unit 650
30 installed in the handpiece and its push button 790 and foot 793 depressed, to thereby facilitate proper location of the switch contact leaves 515G and 523G on opposite sides of the foot 793.

The tubes 23G and 33G are sealingly slipped over their corresponding nipples 632 and 633 (Figures 3B) in a fixed manner (as by press fit) and are lead from the top tub 401G through their respective recesses 634 and 635 and respective communicating hole 640 and notch 641. The cable 27G, which piggybacks the irrigation tube 23G, exits with it through the hole 640 as generally indicated in Figure 1.

As in the incorporated-by-reference application, the pump unit 10G (Figure 1) preferably comprises a pump P driven by a motor M connected in circuit with a battery pack B and conductors 103G of a single pair electric cable 27G piggybacked on the irrigation supply tube 23G leading to the handpiece 26G.

The wires 103G, suitable insulated, terminate within the inverted tub 401G in conventional connectors 525G (Figure 15B) compatible with the electrical connector terminals 514G and 522G, respectively. In the preferred embodiment shown, the connectors 525G are of resilient female type telescopingly fixable on the electrical connector terminals 514G and 522G. In this way, the Figure 15B electrical contact between the leaf 515G and leaf 523G closes the switch SWG, which energizes the pump motor M from the battery B.

With the irrigation push button 790 in its upper, rest position shown in Figures 1, 11A and 16A, the dimetrical through passage 630H is upperwardly displaced from and sealed from the irrigation through passage 630. The foot 793 (Figure 15D) is thus in its uppermost position schematically indicated at 793' where it bends the switch contact leaf 515G to its dotted line position 515G' spaced from the other switch contact leaf 523G such that the switch SWG is in its open, nonconductive

condition and the pump P (Figure 1) is not energized. Because of the closed position of the irrigation valve unit 650, there is no irrigation liquid flow through the handpiece 26G.

5 Partial depression of the irrigation push button 790, as seen in Figures 12A and 16B, brings the irrigation dimetral through passage 720H to partially register with the irrigation throughpassage 630 to provide a fractional flow cross section. Partial
10 depression of the irrigation push button partially depresses the foot 793 (Figures 15B-D) and permits the switch contact leaf 515G to spring further rightward wherein its free end is closer to but not yet in contact with the switch contact leaf 523G. Thus, the switch SWG
15 is still open and the pump P (Figure 1) is still not energized. The pump P is of a type (e.g. a rotating vane pump as in the incorporated-by-reference application) which permits gravity flow of irrigation liquid therethrough when deactuated. Thus, the partial opening
20 of the irrigation valve unit 650 allows gravity flow of irrigation liquid from the irrigation liquid source IL through the chamber of the at-rest pump P, tube 23G, partially open handpiece irrigation valve unit 650, the front end portion 431G of the conduit 430G and thence
25 onward to the surgical site SU, given that the irrigation liquid source IL is, as usual, at a height above that of the handpiece 26G. This provides for a relatively low, gentle flow of irrigation liquid through the handpiece to the surgical site SU, which flow can readily be modulated
30 by movement of the push button 790, foot 793 and irrigation valve body 663H within a range of intermediate positions from closed to (in the preferred embodiment

shown) about 1/3 open. The foot 793 is shown about 1/3 depressed at 793" in Figure 15D.

With slightly further depression, the foot 793 moves out of contact with the switch contact leaf 515G and
5 allows the latter to spring into contact the switch leaf contact 523G, thereby closing the switch SWG (see Figures 15B and D). This through the conductors 103G of the cable 27G thereby closes the circuit of the motor M to the battery B, electrically energizes the motor M from
10 the battery B, and activates the pump P. This condition continues as the pushbutton 790 is depressed through the last portion, e.g. 2/3 of its range.

Also, depression of the irrigation push button 790 (Figure 16C), and thus of the irrigation valve body 663H,
15 through such last portion e.g. 2/3 of their range progressively further opens the latter's diametrical through passage 720H to the irrigation through passage 630, and so progressively further opens the irrigation valve unit 650. Thus, in this part of the range of
20 opening of the irrigation valve unit 650, the activated pump P adds its force to the above mentioned gravitational force, to maximize the pressure of irrigation liquid applied to the irrigation valve unit 630 to the handpiece 26G and thus the extent of opening
25 of irrigation valve unit 650 controls the rate of pumped irrigation flow therethrough to the surgical site SU. Maximum flow rate occurs with the valve unit 650 fully open.

In contrast, in handpieces produced in accord with
30 the incorporated-by-reference application, depression of the irrigation valve pushbutton first actuated the pump and only thereafter began to open the valve, thus

providing no possibility of gravity flow of irrigation liquid through the handpiece.

To complete assembly of the handpiece, the downward opening top tub 401G is placed on the upward opening
5 bottom tub 610, such that the pins 611 of the former enter the corresponding sockets 612 of the latter, thereby seating the top tub 401G firmly on the bottom tub 610 in the matter shown in Figure 1. In the embodiment shown, the lower edge of the top tub 401G includes an
10 inset lip 810 (Figure 2) which rests snugly in the stepped rim 811 of the lower tub 610. The installation of the upper tub 401G on the bottom tub 610 can be made permanent by interposition of a suitable adhesive between the pins 611 and socket 612 or/and between the inset lip
15 810 and stepped rim 811.

The rear end of the conduit 430G is normally sealingly closed by the plug 440G (Figure 2), here with its O-ring 442G and adapter 620. With the O-ring 437G installed on the conduit front end portion 431, any
20 desired tip TP (Figure 1) can be installed in the front end of the conduit 430G. If desired, the rear end of the conduit 430G can be left open to enable insertion through the conduit 430G to a surgical site, any desired elongate tool, e.g. a conventional electrocautery tool (not
25 shown). The internal threads of the conduit rear portion 432 allows threaded, sealed installation of such a tool, which tool may extract through the conduit 430G and through a suitable hollow tip TP to enable the tool to work tissue at the surgical site SU, while yet permitting
30 valved irrigation (gravity or pumped), valved suction, or adjustable constant leak (or by-pass) suction (as for smoke evacuation during electrocautery tissue working), namely by respectively, partial or full depression of the

irrigation valve push button 790, depression to the
desired extent of the suction valve push button 665
or/and appropriate angular setting of the suction leak
control sleeve by means of its arms 674 (Figures 8C and
5 9C).

The ergonomically rounded, easily gripped shelf 400G
(Figures 17 A-D) has a convexly rounded front end 820, a
preferably convexly rounded rear end 821 from which the
tubes 23G and 33G extend generally rearwardly, generally
10 at the angle of the suction duct rear portion 626 to the
conduit 430G. The housing 400G has a bottom wall 822
(Figure 17A) having a convexly rounded front part 823 and
a rear part defining a transverse groove 824 extending
from side-to-side across the bottom wall 822.

15 The shape of the handpiece 26G facilitates
comfortable, secure holding and convenient operation by
the hand H (Figures 17B and 17C) of a user.

For example, in Figure 17B, the user's hand H holds
the handpiece 26G in what may be referred to as an
20 "overhand" position. Here the convexly rounded, bottom
wall, front part 823 is shaped to complement the cupped
palm 836 of the user's hand H and the bottom wall
transverse groove 824 is shaped to complement the web
joining the thumb 830 and first finger 831 of the user's
25 hand H. The elongate conduit 403G is shaped and located
in complement to the joinder of the fingers and palm of
the user's hand. The suction pushbutton 651 and
irrigation pushbutton 790 thus are conveniently
positioned under the tips of the first finger 831 and
30 middle or third fingers 832 or 833 of the user's hand,
for easy depression and release thereby, with such
fingers in the somewhat clenched positions shown in
Figure 17B. The protruding front end of the conduit 430G

and the upstanding irrigation valve barrel 402G define therebetween a notch 834 adapted to receive the little finger 835 of the user's hand H. The handpiece 26G is thus securely gripped in the user's hand H by the thumb 831, palm 836 and little finger 835, leaving the fingers 831-833 free to manipulate the pushbuttons 665 and 790. The arms 674 of the suction leak control sleeve are adjacent the first finger 831 and thumb 830 of the user's hand for rotation by either or both as desired.

10 As a further example and alternative, Figure 17C shows what may be referred to as an "underhand" position for holding and manipulating the handpiece 26G. Here, the handpiece 26G rests in the hand H of the user adjacent the joint of the fingers to the palm with the first finger 831 disposed in the notch 837 defined by the front end of the conduit 430G and the front end 831 of the shell 400G, the index finger 832 engaging the convexly curved front bottom wall portion 823, the third finger 833 disposed in the transverse groove 824 of the bottom wall, and the little finger 834 disposed in the notch 838 (Figure 17A) formed between the rear end 821 and tube 23G. This leaves the thumb 830 free to adjust the position of the arm 674 and depress the pushbuttons 665 and 790.

25 The handpiece 26G may be otherwise positioned in the user's hand H, but the Figure 17B and Figure 17C positions illustrate how the shape of the shell 400G, and the overall arrangement of above discussed parts of the handpiece 26G, facilitate gripping and manipulation of the handpiece 26G by the hand H of a user.

30 Parts of the apparatus above described are preferably of molded, substantially rigid, plastics material of conventional type, except as otherwise

described, e.g. the switch elements 510G and 511G of electrically conductive springy metal, and annular seals 473G and 482G and 486G of conventional resilient rubber-like material, and wires 103D and connectors 525 of
5 electrically conductive metal, and suction leak control sleeve 660 of a resilient self-lubricating material such as polyethylene.

Although a particular preferred embodiment of the invention has been disclosed in detail for illustrative
10 purposes, it will be recognized that variations or modifications of the disclosed apparatus, including the rearrangement of parts, lie within the scope of the present invention.